Day : Sunday
Date: 6/26/2005
Time: 10:07:50

PALM INTRANET

# Inventor Name Search Result

Your Search was:

Last Name = ODAGAWA
First Name = AKIHIRO

| Application# | Patent# | Status | Date Filed | Title | Inventor Name 50 |
|---|---|---|---|---|---|
| 11061920 | Not Issued | 030 | 02/22/2005 | VARIABLE RESISTANCE ELEMENT, METHOD OF MANUFACTURING THE ELEMENT, MEMORY CONTAINING THE ELEMENT, AND METHOD OF DRIVING THE MEMORY | ODAGAWA, AKIHIRO |
| 11060028 | Not Issued | 030 | 02/16/2005 | MAGNETORESISTIVE ELEMENT AND MAGETORESISTIVE MAGNETIC HEAD, MAGNETIC RECORDING APPARATUS AND MAGNETORESISTIVE MEMORY DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 10896795 | Not Issued | 030 | 07/22/2004 | MAGNETIC HEAD AND APPARATUS FOR RECORDING/REPRODUCING MAGNETIC INFORMATION USING THE SAME | ODAGAWA, AKIHIRO |
| 10896774 | Not Issued | 094 | 07/22/2004 | MAGNETIC HEAD COMPRISING A MULTILAYER MAGNETORESISTIVE DEVICE AND A YOKE FOR INTRODUCING MAGNETIC FLUX FROM A MEDIUM TO THE MAGNETORESISTIVE DEVICE | ODAGAWA, AKIHIRO |
| 10877929 | Not Issued | 041 | 06/25/2004 | MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME, AS WELL AS MAGNETIC HEAD, MAGNETIC MEMORY AND MAGNETIC RECORDING DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 10871165 | Not Issued | 030 | 06/18/2004 | MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME | ODAGAWA, AKIHIRO |

| | | | | | |
|---|---|---|---|---|---|
| 10865130 | Not Issued | 020 | 06/10/2004 | THERMAL SWITCHING ELEMENT AND METHOD FOR MANUFACTURING THE SAME | ODAGAWA, AKIHIRO |
| 10848742 | Not Issued | 041 | 05/17/2004 | MAGNETO-RESISTIVE ELEMENT | ODAGAWA, AKIHIRO |
| 10783286 | 6839273 | 150 | 02/20/2004 | MAGNETIC SWITCHING DEVICE AND MAGNETIC MEMORY USING THE SAME | ODAGAWA, AKIHIRO |
| 10732053 | 6861940 | 150 | 12/10/2003 | MAGNETORESISTIVE ELEMENT | ODAGAWA, AKIHIRO |
| 10730096 | Not Issued | 041 | 12/09/2003 | THERMOELECTRIC TRANSDUCING MATERIAL, AND METHOD FOR PRODUCING THE SAME | ODAGAWA, AKIHIRO |
| 10719412 | Not Issued | 094 | 11/21/2003 | MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME, AS WELL AS MAGNETIC HEAD, MAGNETIC MEMORY AND MAGNETIC RECORDING DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 10717059 | Not Issued | 030 | 11/18/2003 | READER AND AUTHENTICATION DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 10695731 | Not Issued | 092 | 10/24/2003 | MAGNETIC MEMORY AND METHOD FOR DRIVING THE SAME, AND MAGNETIC MEMORY DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 10693283 | Not Issued | 041 | 10/24/2003 | MAGNETORESISTIVE ELEMENT AND METHOD FOR MANUFACTURING THE SAME | ODAGAWA, AKIHIRO |
| 10692362 | 6842317 | 150 | 10/22/2003 | MAGNETORESISTIVE ELEMENT, MAGNETIC HEAD, MAGNETIC MEMORY AND MAGNETIC RECORDING APPARATUS USING THE SAME | ODAGAWA, AKIHIRO |
| 10611224 | 6917492 | 150 | 06/27/2003 | MAGNETORESISTIVE ELEMENT AND METHOD FOR MANUFACTURING THE SAME AND NONVOLATILE MEMORY INCLUDING THE SAME | ODAGAWA, AKIHIRO |
| 10470670 | Not Issued | 094 | 07/29/2003 | MAGNETORESISTANCE ELEMENT AND MAGNETORESISTANCE STORAGE ELEMENT AND | ODAGAWA, AKIHIRO |

| | | | | | |
|---|---|---|---|---|---|
| | | | | MAGNETIC MEMORY | |
| 10441794 | 6798620 | 150 | 05/20/2003 | MAGNETO-RESISTIVE ELEMENT, MAGNETIC HEAD, AND MAGNETIC RECORDING AND REPRODUCTION APPARATUS | ODAGAWA, AKIHIRO |
| 10421989 | 6708390 | 150 | 04/23/2003 | METHOD FOR MANUFACTURING MAGNETORESISTIVE ELEMENT | ODAGAWA, AKIHIRO |
| 10362871 | Not Issued | 030 | 02/27/2003 | AUTHENTICATION SYSTEM, AUTHENTICATION REQUEST DEVICE, VALIDATING DEVICE AND SERVICE MEDIUM | ODAGAWA, AKIHIRO |
| 10344296 | Not Issued | 161 | 02/07/2003 | MAGNETORESISTIVE ELEMENT | ODAGAWA, AKIHIRO |
| 10276966 | Not Issued | 161 | 02/19/2003 | MAGNETORESISTIVE ELEMENT AND MAGNETORESISTIVE MAGNETIC HEAD, MAGNETIC RECORDING APPARATUS AND MAGNETORESISTIVE MEMORY DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 10258313 | 6878979 | 150 | 10/18/2002 | SPIN SWITCH AND MAGNETIC STORAGE ELEMENT USING IT | ODAGAWA, AKIHIRO |
| 10250811 | Not Issued | 092 | 07/08/2003 | MAGNETIC STORAGE ELEMENT, PRODUCTION METHOD AND DRIVING METHOD THEREFOR, AND MEMORY ARRAY | ODAGAWA, AKIHIRO |
| 10250319 | 6778427 | 150 | 06/26/2003 | MAGNETORESISTANCE STORAGE ELEMENT | ODAGAWA, AKIHIRO |
| 10223875 | 6887717 | 150 | 08/19/2002 | MAGNETORESISTIVE DEVICE AND METHOD FOR PRODUCING THE SAME, AND MAGNETIC COMPONENT | ODAGAWA, AKIHIRO |
| 10052725 | 6771473 | 150 | 01/18/2002 | MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME | ODAGAWA, AKIHIRO |
| 10038083 | 6555889 | 150 | 01/03/2002 | MAGNETORESISTIVE DEVICE AND METHOD FOR PRODUCING THE SAME, AND MAGNETIC COMPONENT | ODAGAWA, AKIHIRO |
| 10034895 | Not Issued | 030 | 12/28/2001 | MAGNETO-RESISTANCE EFFECT ELEMENT MAGNETO-RESISTANCE EFFECT MEMORY CELL, MRAM, AND METHOD | ODAGAWA, AKIHIRO |

| | | | | | |
|---|---|---|---|---|---|
| | | | | FOR PERFORMING INFORMATION WRITE TO OR READ FROM THE MAGNETO-RESISTANCE EFFECT MEMORY CELL | |
| 10007454 | Not Issued | 161 | 11/08/2001 | MAGNETIC HEAD, AND MAGNETIC RECORDING AND REPRODUCTION APPARATUS | ODAGAWA, AKIHIRO |
| 09969558 | 6717780 | 150 | 10/02/2001 | MAGNETORESISTIVE DEVICE AND/OR MULTI-MAGNETORESISTIVE DEVICE | ODAGAWA, AKIHIRO |
| 09946643 | Not Issued | 041 | 09/04/2001 | MAGNETORESISTIVE ELEMENT, METHOD FOR MANUFACTURING THE SAME, AND MAGNETIC DEVICE USING THE SAME | ODAGAWA, AKIHIRO |
| 09931113 | 6767655 | 150 | 08/16/2001 | MAGNETO-RESISTIVE ELEMENT | ODAGAWA, AKIHIRO |
| 09864564 | 6594120 | 150 | 05/23/2001 | MAGNETORESISTIVE ELEMENT AND MAGNETIC MEMORY ELEMENT AND MAGNETIC HEAD USING THE SAME | ODAGAWA, AKIHIRO |
| 09856847 | 6778425 | 150 | 08/22/2001 | MAGNETORESISTANCE EFFECT MEMORY DEVICE AND METHOD FOR PRODUCING THE SAME | ODAGAWA, AKIHIRO |
| 09829400 | 6785100 | 150 | 04/09/2001 | MAGNETIC HEAD COMPRISING A MULTILAYER MAGNETORESISTIVE DEVICE AND A YOKE FOR INTRODUCING MAGNETIC FLUX FROM A MEDIUM TO THE MAGNETORESISTIVE DEVICE | ODAGAWA, AKIHIRO |
| 09804867 | 6538297 | 150 | 03/13/2001 | MAGNETO-RESISTIVE DEVICE AND MAGNETO-RESISTIVE EFFECT TYPE STORAGE DEVICE | ODAGAWA, AKIHIRO |
| 09803571 | 6590268 | 150 | 03/09/2001 | MAGNETIC CONTROL DEVICE, AND MAGNETIC COMPONENT AND MEMORY APPARATUS USING THE SAME | ODAGAWA, AKIHIRO |
| 09744513 | 6528326 | 150 | 01/24/2001 | MAGNETORESISTIVE DEVICE AND METHOD FOR PRODUCING THE SAME, AND MAGNETIC COMPONENT | ODAGAWA, AKIHIRO |
| 09597691 | Not | 161 | 06/19/2000 | SUPERCONDUCTING DEVICE | ODAGAWA, |

| | | | | | |
|---|---|---|---|---|---|
| | Issued | | | AND A METHOD OF MANUFACTURING THE SAME | AKIHIRO |
| 09596116 | 6436526 | 150 | 06/16/2000 | MAGNETO-RESISTANCE EFFECT ELEMENT, MAGNETO-RESISTANCE EFFECT MEMORY CELL, MRAM AND METHOD FOR PERFORMING INFORMATION WRITE TO OR READ FROM THE MAGNETO-RESISTANCE EFFECT MEMORY CELL | ODAGAWA, AKIHIRO |
| 09212721 | 6074768 | 150 | 12/16/1998 | PROCESS FOR FORMING THE OXIDE SUPERCONDUCTOR THIN FILM AND LAMINATE OF THE OXIDE SUPERCONDUCTOR THIN FILMS | ODAGAWA, AKIHIRO |
| 09082761 | 6147360 | 150 | 05/21/1998 | SUPERCONDUCTING DEVICE AND A METHOD OF MANUFACTURING THE SAME | ODAGAWA, AKIHIRO |
| 08888657 | 5885937 | 150 | 07/07/1997 | SUPERCONDUCTING TUNNEL JUNCTION ELEMENT AND SUPERCONDUCTING DEVICE | ODAGAWA, AKIHIRO |
| 08880914 | 5885939 | 150 | 06/23/1997 | PROCESS FOR FORMING A-AXIS-ON-C-AXIS DOUBLE-LAYER OXIDE SUPERCONDUCTOR FILMS | ODAGAWA, AKIHIRO |
| 08803940 | 6160266 | 150 | 02/20/1997 | SUPERCONDUCTING DEVICE AND A METHOD OF MANUFACTURING THE SAME | ODAGAWA, AKIHIRO |
| 08410447 | Not Issued | 166 | 03/24/1995 | PROCESS FOR FORMING THE OXIDE SUPERCONDUCTOR THIN FILM AND LAMINATE OF THE OXIDES SUPERCONDUCTOR THIN FILMS | ODAGAWA, AKIHIRO |
| 08328328 | 5719105 | 150 | 10/24/1994 | SUPERCONDUCTING ELEMENT | ODAGAWA, AKIHIRO |
| 08199813 | Not Issued | 161 | 02/22/1994 | OXIDE THIN FILM FORMING APPARATUS AND PROCESS OF FORMING THE OXIDE THIN FILM | ODAGAWA, AKIHIRO |

Search and Display More Records.

**Search Another: Inventor** **Last Name** Odagawa **First Name** Akihiro Search

To go back use Back button on your browser toolbar.

Back to PALM | ASSIGNMENT | OASIS | Home page

# Hit List

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

**Search Results -** Record(s) 1 through 10 of 14 returned.

☐ 1. Document ID: US 20050111124 A1

AB: A master carrier for magnetic transfer is equipped with a substrate having a land/groove pattern. The land/groove pattern is formed from a magnetic material and corresponds to information that is transferred to a magnetic recording disk. Each land in the land/groove pattern has four round corners whose radius is from 1% through 47% of the width of a data track on the disk.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des

☐ 2. Document ID: US 20050024786 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. A first self-pinned layer having a first magnetic orientation is provided, wherein the first self-pinned layer has a first end, a second end and central portion. A second self-pinned layer is formed over only the central portion of the first self-pinned layer and an interlayer is disposed between the first and second self-pinned layers. A free layer is formed in a central region over the second self-pinned layer. First and second hard bias layers are formed over the first and second ends of the first self-pinned layer respectively, the first and second hard bias layer abutting the free layer, the first and second end of the first self-pinned layer extending under the hard bias layers at the first and second ends.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des

☐ 3. Document ID: US 20050024785 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a free layer having a first end and a second end defining a width selected to form a desired trackwidth and an extended self-pinned bias layer extending beyond the ends of the free layer, the self-pinned bias layer extending beyond the free layer increasing the volume of the extended self-pinned bias layer to provide greater thermal stability and stronger pinning of the free layer.

| Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

---

☐ 4. Document ID: US 20050024784 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a sandwiched hard bias layer having a first hard bias layer coupled to a free layer and a second, anti-parallel hard bias layer disposed away form the free layer to provide a net longitudinal bias on the free layer.

| Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

---

☐ 5. Document ID: US 20050024783 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a self-pinned layer, the self-pinned layer having a first end, a second end and central portion, a free layer disposed over the central portion of the self-pinned layer in a central region and a first and second hard bias layers formed over the first and second ends of the self-pinned layer respectively, the first and second hard bias layer abutting the free layer, the first and second end of the self-pinned layer extending under the hard bias layers at the first and second ends.

| Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

---

☐ 6. Document ID: US 20040120082 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a free layer having a first end and a second end defining a width selected to form a desired trackwidth and an extended self-pinned bias layer extending beyond the ends of the free layer, the self-pinned bias layer extending beyond the free layer increasing the volume of the extended self-pinned bias layer to provide greater thermal stability and stronger pinning of the free layer.

| Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

---

☐ 7. Document ID: US 20030063403 A1

AB: A master carrier for magnetic transfer is equipped with a substrate having a land/groove pattern. The land/groove pattern is formed from a magnetic material and corresponds to information that is transferred to a magnetic recording disk. Each land in the land/groove pattern has four round corners whose radius is from 1% through 47% of the width of a data track on the disk.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw Des

---

☐ 8. Document ID: US 20030002182 A1

AB: A magnetic transfer device for bringing a master carrier with information and a slave medium into intimate contact with each other and then applying a transfer field to transfer the information to the slave medium. The master carrier has an inclined face on its radially outer end. After the magnetic transfer of the information, claws are inserted in the gas formed by the inclined face of the master carrier and the slave medium. The slave medium held in intimate contact with the master carrier is separated from the master carrier by lifting the slave medium with the claws.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw Des

---

☐ 9. Document ID: US 20020081461 A1

AB: There are provided an information recording medium which permits accurate tracking servo, and a method for recording and reproducing for an information recording medium which allows recording and reproducing of a signal at a favorable S/N by carrying out at least one of information recording and information reproduction while accurately performing tracking servo. A magneto-optic disk includes a magnetic recording layer for magnetically recording information. The magnetic recording layer is in advance magnetized for concentrically or spirally around the center of the disk in such a manner that magnetized regions are disposed such that adjacent regions are magnetized in different directions and alternately arranged in the radial direction of the disk. Accordingly, tracking can be continuously performed and accurate tracking servo can also be performed.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw Des

---

☐ 10. Document ID: US 20020058158 A1

AB: A magneto-resistive effect element includes a first ferromagnetic film; a second ferromagnetic film; and a first nonmagnetic film interposed between the first ferromagnetic film and the second

ferromagnetic film. The first ferromagnetic film has a magnetization more easily rotatable than a magnetization of the second ferromagnetic film by an external magnetic field. The first ferromagnetic film has an effective magnetic thickness of about 2 nm or less.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

| Terms | Documents |
|---|---|
| L4 and amorphous | 14 |

**Display Format:** AB Change Format

Previous Page Next Page Go to Doc#

# Hit List

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs
Generate OACS

**Search Results -** Record(s) 11 through 14 of 14 returned.

---

☐ 11. Document ID: US 6909563 B2

AB: A master carrier for magnetic transfer is equipped with a substrate having a land/groove pattern. The land/groove pattern is formed from a magnetic material and corresponds to information that is transferred to a magnetic recording disk. Each land in the land/groove pattern has four round corners whose radius is from 1% through 47% of the width of a data track on the disk.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des

---

☐ 12. Document ID: US 6906875 B2

AB: A magnetic transfer device for bringing a master carrier with information and a slave medium into intimate contact with each other and then applying a transfer field to transfer the information to the slave medium. The master carrier has an inclined face on its radially outer end. After the magnetic transfer of the information, claws are inserted in the gas formed by the inclined face of the master carrier and the slave medium. The slave medium held in intimate contact with the master carrier is separated from the master carrier by lifting the slave medium with the claws.

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Des

---

☐ 13. Document ID: US 6829201 B2

AB: There are provided an information recording medium which permits accurate tracking servo, and a method for recording and reproducing for an information recording medium which allows recording and reproducing of a signal at a favorable S/N by carrying out at least one of information recording and information reproduction while accurately performing tracking servo. A magneto-optic disk includes a magnetic recording layer for magnetically recording information. The magnetic recording layer is in advance magnetized for concentrically or spirally around the center of the disk in such a manner that magnetized regions are disposed such that adjacent regions are magnetized in different directions and alternately arranged in the radial direction of the disk. Accordingly, tracking can be continuously performed and accurate tracking servo can also be performed.

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. Des

☐ 14. Document ID: US 6436526 B1

AB: A magneto-resistive effect element includes a first ferromagnetic film; a second ferromagnetic film; and a first nonmagnetic film interposed between the first ferromagnetic film and the second ferromagnetic film. The first ferromagnetic film has a magnetization more easily rotatable than a magnetization of the second ferromagnetic film by an external magnetic field. The first ferromagnetic film has an effective magnetic thickness of about 2 nm or less.

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. Des

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

| Terms | Documents |
| --- | --- |
| L4 and amorphous | 14 |

**Display Format:** AB Change Format

Previous Page  Next Page  Go to Doc#

Day : Sunday
Date: 6/26/2005
Time: 10:19:27

PALM INTRANET

## Application Number Information

Application Number: **10/848742**
**Assignments**
Examiner Number: **78081 / BERNATZ, KEVIN**
Filing or 371(c) Date: **05/17/2004**
Group Art Unit: **1773**
**IFW IMAGE**
Effective Date: **05/17/2004**
Class/Subclass: **428/692.000**
Application Received: **05/20/2004**
Lost Case: **NO**
Waiting for Response Desc.
**Mail Non Final**
Pat. Num./Pub. Num: **/20040213071**
Interference Number:
Issue Date: **00/00/0000**
Unmatched Petition: **NO**
Date of Abandonment: **00/00/0000**
L&R Code: Secrecy Code:**1**
Attorney Docket Number: **10873.792USD1**
Third Level Review: **NO**
Secrecy Order: **NO**
Status: **41 /NON FINAL ACTION MAILED**
Status Date: **04/14/2005**
Confirmation Number: **7331**
Oral Hearing: **NO**
Title of Invention: **MAGNETO-RESISTIVE ELEMENT**

| Bar Code | PALM Location | Location Date | Charge to Loc | Charge to Name | Employee Name | Location |
|---|---|---|---|---|---|---|

**Appln Info** Contents | Petition Info | Atty/Agent Info | Continuity Data | Foreign Data | Inve

**Search Another: Application#** Search **or Patent#** Search
**PCT /** / Search **or PG PUBS #** Search
**Attorney Docket #** Search
**Bar Code #** Search

To go back use Back button on your browser toolbar.

Back to PALM | ASSIGNMENT | OASIS | Home page

# US PATENT & TRADEMARK OFFICE
## PATENT APPLICATION FULL TEXT AND IMAGE DATABASE





**United States Patent Application** *20040213071*
**Kind Code** **A1**
**Hiramoto, Masayoshi ; et al.** **October 28, 2004**

Magneto-resistive element

**Abstract**

The present invention provides a vertical current-type magneto-resistive element. The element includes an intermediate layer and a pair of magnetic layers sandwiching the intermediate layer, and at least one of a free magnetic layer and a pinned magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer. The element area defined by the area of the intermediate layer through which current flows perpendicular to the film is not larger than 1000 .mu.m.sup.2.

| | |
|---|---|
| Inventors: | **Hiramoto, Masayoshi**; *(Ikoma-shi, JP)* ; **Matukawa, Nozomu**; *(Nara-shi, JP)* ; **Odagawa, Akihiro**; *(Nara-shi, JP)* ; **Iijima, Kenji**; *(Kyoto-shi, JP)* ; **Sakakima, Hiroshi**; *(Kyotanabe-shi, JP)* |
| Correspondence Name and Address: | **MERCHANT & GOULD PC**<br>**P.O. BOX 2903**<br>**MINNEAPOLIS**<br>**MN**<br>**55402-0903**<br>**US** |
| Assignee Name and Adress: | **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**<br>**Kadoma-shi**<br>**JP**<br>**571-8501** |

| | |
|---|---|
| Serial No.: | **848742** |
| Series Code: | **10** |
| Filed: | **May 17, 2004** |

**U.S. Current Class:** **365/232**; 257/E21.665; 257/E27.005

**[redacted].S. Class at Publication:** **365/232**
**Intern'l Class:** G11C 008/02

*Foreign Application Data*

| Date | Code | Application Number |
|---|---|---|
| Aug 21, 2000 | JP | 2000-249340 |
| Oct 30, 2000 | JP | 2000-330254 |

*Claims*

1. A magneto-resistive element, comprising: an intermediate layer; and a pair of magnetic layers sandwiching the intermediate layer; wherein one of the magnetic layers is a free magnetic layer in which magnetization rotation with respect to an external magnetic field is easier than in the other magnetic layer; wherein the free magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than 1000 .mu.m.sup.2; and the non-magnetic layer has a thickness d in the range of 2.6 nm.ltoreq.d<10 nm.

2. The magneto-resistive element according to claim 1, wherein an area of the free magnetic layer is larger than the element area.

3. The magneto-resistive element according to claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm.times.dm for odd m is substantially equal to the sum of the products Mm.times.dm for even m.

4. (Cancelled)

5. The magneto-resistive element according to any of claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm.times.dm for odd m is different from the sum of the products Mm.times.dm for even m.

6-11 (Cancelled)

12. The magneto-resistive element according to claim 5, further comprising a second intermediate layer, wherein the free magnetic layer, which is made of a multilayer film, is sandwiched by the intermediate layers.

13. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of 2n magnetic layers (with n being an integer of 1 or greater) and 2n-1 non-magnetic layers layered in alternation.

14. The magneto-resistive element according to claim 13, further comprising a first pinned magnetic

layer and a second pinned magnetic layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a non-magnetic layer and a second magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n (with n being 1 or 2) is dn, and its average saturation magnetization is Mn, then M2.times.d2.noteq.M1.tim- es.d1.

15. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of 2n+1 magnetic layers (with n being an integer of 1 or greater) and 2n non-magnetic layers layered in alternation.

16. The magneto-resistive element according to claim 15, further comprising a first pinned magnetic layer and a second pinned layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a first non-magnetic layer, a second magnetic layer, a second non-magnetic layer and a third magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n is dn (with n being 1, 2 or 3), and its average saturation magnetization is Mn, then M3.times.d3+M1.times.d1.noteq.M2.tim- es.d2.

17. The magneto-resistive element according to claim 1, wherein at least one of the magnetic layers in the free magnetic layer has a coercivity or saturation magnetization that is different from at least one of the other magnetic layers.

18-38 (Cancelled)

39. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

40. (Cancelled)

41. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of at least one metal selected from transition metals, or at least one conductive compound selected from compounds of transition metals with oxygen, nitrogen and boron; and wherein the element area is not larger than 0.01 .mu.m.sup.2.

42. The magneto-resistive element according to claim 41, wherein at least one of the magnetic layers sandwiching the intermediate layer comprises a ferromagnetic material including oxygen, nitrogen or carbon, or an amorphous ferromagnetic material.

43-44 (Cancelled)

45. The magneto-resistive element according to claim 1, wherein the free magnetic layer serves as a magnetic memory layer.

46. (Cancelled)

47. The magneto-resistive element according to claim 1, further comprising a flux guide.

48. The magneto-resistive element according to claim 47, wherein at least a portion of the free magnetic layer serves as the flux guide.

49-50 (Cancelled)

51. The magneto-resistive element according to claim 1, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of 1.5<a/b<10.

52-58 (Cancelled)

59. A data communication terminal equipped with a plurality of magneto-resistive elements according to claim 1, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto-resistive elements.

60. (Cancelled)

61. The magneto-resistive element according to claim 12, comprising a first pinned magnetic layer, a first intermediate layer, a first free magnetic layer, a non-magnetic conductive layer, a second free magnetic layer, an second intermediate layer and a second pinned magnetic layer formed in that order, wherein at least one of the first free magnetic layer and the second free magnetic layer includes one or more magnetic layers and one or more non-magnetic layers layered in alternation.

62. The magneto-resistive element according to claim 61, wherein magnetic layers that are adjacent but spaced apart by a non-magnetic conductive layer are magnetized antiparallel to one another.

63. The magneto-resistive element according to claim 61, wherein the non-magnetic conductive layer has a thickness of 2.6 nm to 50 nm.

64. (Cancelled)

65. The magneto-resistive element according to claim 1, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10 wt % to 50 wt % of a non-magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2 T.

66. The magneto-resistive element according to claim 65, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.

67-68 (Cancelled)

69. The magneto-resistive element according to claim 1, wherein the free magnetic layer is made of at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4 nm.

70. (Cancelled)

71. The magneto-resistive element according to claim 1, wherein the non-magnetic layer comprises at least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

Day : Sunday
Date: 6/26/2005
Time: 10:33:00

PALM INTRANET

## Application Number Information

Application Number: **09/931113**
**Assignments**
Examiner Number: **79025 / UHLIR, NIKOLAS**
Filing or 371(c) Date: **08/16/2001**
Group Art Unit: 1773
**IFW IMAGE**
Effective Date: **08/16/2001**
Class/Subclass: **428/692.000**
Application Received: **08/17/2001**
Lost Case: **NO**
Pat. Num./Pub. Num: 6767655/20020055016
Interference Number:
Issue Date: **07/27/2004**
Unmatched Petition: **NO**
Date of Abandonment: **00/00/0000**
L&R Code: Secrecy Code:**1**
Attorney Docket Number: **10873.792US01**
Third Level Review: **NO**
Secrecy Order: **NO**
Status: **150 /PATENTED CASE**
Status Date: **07/08/2004**
Confirmation Number: **3656**
Oral Hearing: **NO**
Title of Invention: **MAGNETO-RESISTIVE ELEMENT**

| Bar Code | PALM Location | Location Date | Charge to Loc | Charge to Name | Employee Name | Location |
|---|---|---|---|---|---|---|

**Appln Info** Contents | Petition Info | Atty/Agent Info | Continuity Data | Foreign Data | Inve

**Search Another: Application#** [ ] Search **or Patent#** [ ] Search
**PCT /** [ ] / [ ] Search **or PG PUBS #** [ ] Search
**Attorney Docket #** [ ] Search
**Bar Code #** [ ] Search

To go back use Back button on your browser toolbar.

Back to PALM | ASSIGNMENT | OASIS | Home page

| | |
|---|---|
| **United States Patent Application** | ***20020055016*** |
| **Kind Code** | **A1** |
| **Hiramoto, Masayoshi ; et al.** | **May 9, 2002** |

# Magneto-resistive element

**Abstract**

The present invention provides a vertical current-type magneto-resistive element. The element includes an intermediate layer and a pair of magnetic layers sandwiching the intermediate layer, and at least one of a free magnetic layer and a pinned magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer. The element area defined by the area of the intermediate layer through which current flows perpendicular to the film is not larger than 1000 .mu.m.sup.2.

| | |
|---|---|
| Inventors: | **Hiramoto, Masayoshi**; *(Nara, JP)* ; **Matukawa, Nozomu**; *(Nara, JP)* ; **Odagawa, Akihiro**; *(Nara, JP)* ; **Iijima, Kenji**; *(Kyoto, JP)* ; **Sakakima, Hiroshi**; *(Kyoto, JP)* |
| Correspondence Name and Address: | **MERCHANT & GOULD PC<br>P.O. BOX 2903<br>MINNEAPOLIS<br>MN<br>55402-0903<br>US** |

| | |
|---|---|
| Serial No.: | **931113** |
| Series Code: | **09** |
| Filed: | **August 16, 2001** |

| | |
|---|---|
| **U.S. Current Class:** | **428/692**; 257/E21.665; 257/E27.005 |
| **U.S. Class at Publication:** | **428/692** |
| **Intern'l Class:** | G11B 005/127; B32B 009/00 |

*Foreign Application Data*

| Date | Code | Application Number |
|---|---|---|

| | | |
|---|---|---|
| Aug 21, 2000 | JP | 2000-249340 |
| Oct 30, 2000 | JP | 2000-330254 |

## *Claims*

What is claimed is:

1. A magneto-resistive element, comprising: an intermediate layer; and a pair of magnetic layers sandwiching the intermediate layer; wherein one of the magnetic layers is a free magnetic layer in which magnetization rotation with respect to an external magnetic field is easier than in the other magnetic layer; wherein the free magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; and wherein an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than 1000 .mu.m.sup.2.

2. The magneto-resistive element according to claim 1, wherein an area of the free magnetic layer is larger than the element area.

3. The magneto-resistive element according to claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm.times.dm for odd m is substantially equal to the sum of the products Mm.times.dm for even m.

4. The magneto-resistive element according to claim 3, the non-magnetic layer has a thickness d in the range of 2.6 nm.ltoreq.d<10 nm.

5. The magneto-resistive element according to any of claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm.times.dm for odd m is different from the sum of the products Mm.times.dm for even m.

6. The magneto-resistive element according to claim 5, the non-magnetic layer has a thickness d in the range of 2.6 nm.ltoreq.d<10 nm.

7. The magneto-resistive element according to claim 5, wherein the non-magnetic layer has a thickness d in the range of 0.3 nm<d<2.6 nm.

8. The magneto-resistive element according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2, then1.1<(M1.times.d1+M2.times.d2)/S<20;(wherei- n S is the absolute value of M1.times.d1-M2.times.d2); and 1) taking the effective film thickness d11 of the first magnetic layer as d11=(M1.times.d1-M2.times.d2)/M1 when M1.times.d1-M2.times.d2>0, and 2) taking the effective film thickness d22 of the second magnetic layer as d22 =(M2.times.d2-M1.times.d1)/M1 when M1.times.d1-M2.times.d2<0, and taking as Nm the demagnetizing factor in a free magnetic layer surface in a direction of an applied external magnetic field, determined from the

effective film thickness d11 or d22 and the free magnetic layer surface shape, then Nm<0.02.

9. The magneto-resistive element according to claim 5, wherein, when the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2, thenM2.times.d2>M1.times.d1; andwherein the second magnetic layer is made of a soft magnetic material or a hard magnetic material, and the first magnetic layer is made of a high spin polarization material at least at an interface with the intermediate layer.

10. The magneto-resistive element according to claim 5, wherein, when the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2, thenM2.times.d2>M1.times.d1; andthe magnetic resistance displays at least one maximum or minimum with respect to a change in the external magnetization.

11. The magneto-resistive element according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a first non-magnetic layer, second magnetic layer, a second non-magnetic layer, and a third magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the magnetic layer n is dn, and its average saturation magnetization is Mn (with n=1, 2, 3), thenM3.times.d3>M1.times.d1 and M3.times.d3>M2.times.d2; andwherein a coupling magnetic field of the first magnetic layer and the second magnetic layer is smaller than a memory reversal magnetic field, and the magnetization state of the third magnetic layer is detected by applying a magnetic field that is smaller than the memory reversal magnetic field but larger than the coupling magnetic field in a memory direction of the magnetization of the third magnetic layer.

12. The magneto-resistive element according to claim 5, further comprising a second intermediate layer, wherein the free magnetic layer, which is made of a multilayer film, is sandwiched by the intermediate layers.

13. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of 2n magnetic layers (with n being an integer of 1 or greater) and 2n-1 non-magnetic layers layered in alternation.

14. The magneto-resistive element according to claim 13, further comprising a first pinned magnetic layer and a second pinned magnetic layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a non-magnetic layer and a second magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n (with n being 1 or 2) is dn, and its average saturation magnetization is Mn, then M2.times.d2.noteq.M1.times.d1.

15. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of 2n+1 magnetic layers (with n being an integer of 1 or greater) and 2n non-magnetic layers layered in alternation.

16. The magneto-resistive element according to claim 15, further comprising a first pinned magnetic layer and a second pinned layer, wherein the first pinned magnetic layer, the first intermediate layer, the

free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a first non-magnetic layer, a second magnetic layer, a second non-magnetic layer and a third magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n is dn (with n being 1, 2 or 3), and its average saturation magnetization is Mn, then M3.times.d3+M1.times.d1.noteq.M2.tim- es.d2.

17. The magneto-resistive element according to claim 1, wherein at least one of the magnetic layers in the free magnetic layer has a coercivity or saturation magnetization that is different from at least one of the other magnetic layers.

18. A magneto-resistive element comprising: a magneto-resistive element A according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and wherein M2.times.d2>M1.times.d1, when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2; and further comprising a magneto-resistive element B having a second intermediate layer and a free magnetic layer that comprises a third magnetic layer and a fourth magnetic layer positioned in that order from the second intermediate layer, and wherein M3.times.d3>M4.times.d4, when an average film thickness of the third magnetic layer is d3, its average saturation magnetization is M3, an average film thickness of the fourth magnetic layer is d4, and its average saturation magnetization is M4; wherein the element A and the element B respond to the same external magnetic field, and the output of element A and element B are added to or subtracted from one another.

19. A magneto-resistive element, comprising: an intermediate layer; and a pair of magnetic layers sandwiching the intermediate layer; wherein one of the magnetic layers is a pinned magnetic layer in which magnetization rotation with respect to an external magnetic field is more difficult than in the other magnetic layer; wherein the pinned magnetic layer is a multilayer film comprising at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; wherein a thickness d of the non-magnetic layer is in the range of 0.3 nm<d<2.6 nm; wherein the pinned magnetic layer is in contact with a primer layer or an antiferromagnetic layer; and wherein an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than 1000 .mu.m.sup.2.

20. The magneto-resistive element according to claim 19, wherein, when the magnetic layers m are the magnetic layers in the pinned magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm.times.dm for odd m is substantially equal to the sum of the products Mm.times.dm for even m.

21. A magneto-resistive element comprising: a magneto-resistive element A including a first pinned magnetic layer, in which 2n magnetic layers and 2n-1 non-magnetic layers (with n being an integer of 1 or greater) are layered in alternation from the intermediate layer; and a magneto-resistive element B, including a second pinned magnetic layer, in n which 2n+1 magnetic layers and 2n non-magnetic layers are layered in alternation from the intermediate layer; wherein at least one of the element A and the element B is as claimed in claim 19; wherein the element A and the element B respond to the same external magnetic field; and wherein the outputs of element A and element B are added to or subtracted from one another.

22. The magneto-resistive element according to claim 19, wherein the non-magnetic layer comprises at

least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

23. The magneto-resistive element according to claim 22, wherein the non-magnetic layer is a multilayer film including at least one layer of non-magnetic metal and at least one layer of non-magnetic material selected from the group consisting of oxides, nitrides, carbides and borides.

24. The magneto-resistive element according to claim 19, wherein the primer layer includes at least one element selected from the elements of groups IVa to VIa and VIII (but excluding Fe, Co and Ni) and Cu.

25. The magneto-resistive element according to claim 19, wherein the primer layer is in contact with a magnetic layer, and the primer layer and that magnetic layer have at least one crystal structure selected from fcc and hcp structure, or the primer layer and that magnetic layer both include a bcc structure.

26. The magneto-resistive element according to claim 19, wherein the antiferromagnetic layer is made of Cr and at least one selected from the group consisting of Mn, Tc, Ru, Rh, Re, Os, Ir, Pd, Pt, Ag, Au and Al.

27. The magneto-resistive element according to claim 26, wherein the antiferromagnetic layer has a composition that can be expressed by Cr.sub.100-xMe.sub.x (wherein Me is at least one selected from the group consisting of Re, Ru and Rh, and 0.1.ltoreq.X.ltoreq.20).

28. The magneto-resistive element according to claim 19, wherein the antiferromagnetic layer has a composition that can be expressed by Mn.sub.100-xMe.sub.x (wherein Me is at least one selected from the group consisting of Pd Pt, and 40.ltoreq.X.ltoreq.55).

29. The magneto-resistive element according to claim 19, wherein the antiferromagnetic layer is formed on a primer layer, and the primer layer and the antiferromagnetic layer include at least one crystal structure selected from fcc, fct, hcp and hct structure, or the primer layer and the antiferromagnetic layer both include a bcc structure.

30. The magneto-resistive element according to claim 29, wherein the primer layer is made of NiFe or NiFeCr; and which has been thermally processed at a temperature of at least 300.degree. C.

31. The magneto-resistive element according to claim 19, wherein at least the magnetic layer in contact with the antiferromagnetic layer is made of Co.

32. The magneto-resistive element according to claim 19, wherein the magnetic layer in contact with at least one selected from the antiferromagnetic layer and the non-magnetic layer is made of a ferromagnetic material including at least one element selected from the group consisting of oxygen, nitrogen and carbon.

33. The magneto-resistive element according to claim 19, wherein the magnetic layer in contact with at least one selected from the antiferromagnetic layer and the non-magnetic layer is made of an amorphous ferromagnetic material.

34. The magneto-resistive element according to claim 19, wherein, when df is a thickness of the pinned magnetic layer, and da is a thickness of the ferromagnetic layer, then 2 nm.ltoreq.df.ltoreq.50 nm, 5 nm.ltoreq.da.ltoreq.100 nm, 0.1 nm.ltoreq.df/da.ltoreq.5.

35. The magneto-resistive element according to claim 1, further comprising a lower electrode made of a

metal multilayer film, wherein the magneto-resistive element is formed on the lower electrode.

36. The magneto-resistive element according to claim 35, wherein the multilayer film has a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al and Cu as a main component, and a grain-growth suppression layer of an metal having at least one element selected from groups IVa to VIa and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, conductive nitrides and conductive carbides.

37. The magneto-resistive element according to claim 19, further comprising a lower electrode made of a metal multilayer film, wherein the magneto-resistive element is formed on the lower electrode.

38. The magneto-resistive element according to claim 37, wherein the multilayer film has a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al and Cu as a main component, and a grain-growth suppression layer of an metal having at least one element selected from groups IVa to VIa and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, conductive nitrides and conductive carbides.

39. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

40. The magneto-resistive element according to claim 19, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

41. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of at least one metal selected from transition metals, or at least one conductive compound selected from compounds of transition metals with oxygen, nitrogen and boron; and wherein the element area is not larger than 0.01 .mu.m.sup.2.

42. The magneto-resistive element according to claim 41, wherein at least one of the magnetic layers sandwiching the intermediate layer comprises a ferromagnetic material including oxygen, nitrogen or carbon, or an amorphous ferromagnetic material.

43. The magneto-resistive element according to claim 19, wherein the intermediate layer is made of at least one metal selected from transition metals, or at least one conductive compound selected from compounds of transition metals with oxygen, nitrogen and boron; and wherein the element area is not larger than 0.01 .mu.m.sup.2.

44. The magneto-resistive element according to claim 43, wherein at least one of the magnetic layers sandwiching the intermediate layer comprises a ferromagnetic material including oxygen, nitrogen or carbon, or an amorphous ferromagnetic material.

45. The magneto-resistive element according to claim 1, wherein the free magnetic layer serves as a magnetic memory layer.

46. The magneto-resistive element according to claim 19, wherein the free magnetic layer serves as a magnetic memory layer.

47. The magneto-resistive element according to claim 1, further comprising a flux guide.

48. The magneto-resistive element according to claim 47, wherein at least a portion of the free magnetic layer serves as the flux guide.

49. The magneto-resistive element according to claim 19, further comprising a flux guide.

50. The magneto-resistive element according to claim 49, wherein at least a portion of the free magnetic layer serves as the flux guide.

51. The magneto-resistive element according to claim 1, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of 1.5<a/b<10.

52. The magneto-resistive element according to claim 19, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of 1.5<a/b<10.

53. A method for manufacturing a magneto-resistive element according to claim 1, comprising additional heat treatment in a magnetic field at 200.degree. C. to 400.degree. C., after heat treatment at 300.degree. C. to 450.degree. C.

54. A method for manufacturing a magneto-resistive element according to claim 19, comprising additional heat treatment in a magnetic field at 200.degree. C. to 400.degree. C., after heat treatment at 300.degree. C. to 450.degree. C.

55. A method for manufacturing a magneto-resistive element according to claim 1, comprising heat treatment in a magnetic field at 300.degree. C. to 450.degree. C.

56. A method for manufacturing a magneto-resistive element according to claim 19, comprising heat treatment in a magnetic field at 300.degree. C. to 450.degree. C.

57. A method for manufacturing a magneto-resistive element according to claim 1, comprising: forming a multilayer film including an antiferromagnetic layer, a pinned layer, an intermediate layer and a free magnetic layer on a substrate; providing a uniaxial anisotropy by performing heat treatment in a magnetic field at 200.degree. C. to 350.degree. C.; performing additional heat treatment in a reducing atmosphere at 300.degree. C. to 450.degree. C.

58. A method for manufacturing a magneto-resistive element according to claim 19, comprising: forming a multilayer film including an antiferromagnetic layer, a pinned layer, an intermediate layer and a free magnetic layer on a substrate; providing a uniaxial anisotropy by performing heat treatment in a magnetic field at 200.degree. C. to 350.degree. C.; performing additional heat treatment in a reducing atmosphere at 300.degree. C. to 450.degree. C.

59. A data communication terminal equipped with a plurality of magneto-resistive elements according to claim 1, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto-resistive elements.

60. A data communication terminal equipped with a plurality of magneto-resistive elements according to claim 19, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto-resistive elements.

61. The magneto-resistive element according to claim 12, comprising a first pinned magnetic layer, a first intermediate layer, a first free magnetic layer, a non-magnetic conductive layer, a second free magnetic layer, an second intermediate layer and a second pinned magnetic layer formed in that order, wherein at least one of the first free magnetic layer and the second free magnetic layer includes one or more magnetic layers and one or more non-magnetic layers layered in alternation.

62. The magneto-resistive element according to claim 61, wherein magnetic layers that are adjacent but spaced apart by a non-magnetic conductive layer are magnetized antiparallel to one another.

63. The magneto-resistive element according to claim 61, wherein the non-magnetic conductive layer has a thickness of 2.6 nm to 50 nm.

64. The magneto-resistive element according to claim 12, comprising four pinned magnetic layers, two free magnetic layers, and four intermediate layers, wherein at least one of the free magnetic layers is made of one or more magnetic layers and one or more non-magnetic layers layered in alternation.

65. The magneto-resistive element according to claim 1, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10 wt % to 50 wt % of a non-magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2 T.

66. The magneto-resistive element according to claim 65, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.

67. The magneto-resistive element according to claim 19, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10 wt % to 50 wt % of a non-magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2 T.

68. The magneto-resistive element according to claim 67, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.

69. The magneto-resistive element according to claim 1, wherein the free magnetic layer is made of at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4 nm.

70. The magneto-resistive element according to claim 19, wherein the free magnetic layer is made of at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4 nm.

71. The magneto-resistive element according to claim 1, wherein the non-magnetic layer comprises at least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

72. The magneto-resistive element according to claim 71, wherein the non-magnetic layer is a multilayer film including at least one layer of non-magnetic metal and at least one layer of non-magnetic material selected from the group consisting of oxides, nitrides, carbides and borides.

---

***Description***